TETA TO-0013
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TEST EFFECTIVENESS TREND OBSERVATION

Impact of Hardware Complexity on Problems Failures

CONCLUSION:

The increase in the percentage of problems/failures (P/Fs) on electrical and electronic assemblies, from Voyager to Galileo, is directly proportional to the hardware complexity as indicated by part count.

DISCUSSION:

The number of (P/Fs), resulting from environmental testing on Voyager and Galileo, was classified according to hardware type for spacecraft hardware exclusive of instruments. The classification was performed by counting P/Fs and assigning them to hardware type on the basis of what was perceived as the predominant hardware of the assembly in which they occurred. Because of the large number of assemblies, only P/Fs resulting from three causes were considered: parts; design; and workmanship & manufacturing. Three hardware types were considered: mechanical; electrical & electronic; propulsion & pyro.

Figure 1 gives the percentage of P/Fs broken down per hardware type at the assembly level. The significant thing that Figure 1 shows is that the preponderance of P/Fs occur in electrical and electronic hardware compared to the other two classifications. This follows from the preponderance of hardware associated with electrical functions contrasted with mechanical and propulsion functions. Of the 14 subsystems considered for Voyager, 10 were considered to be primarily electrical in nature; while for Galileo, 9 out of 13 were electrical in nature.

Several parameters have been considered as a measure of hardware electrical complexity. The most common is the total number of electronic parts. Other parameters, such as the number of "equivalent transistors," may be more directly related to the state of technology. Comparisons between S/C complexity can also be made based on characteristics or parameters of the S/C subsystems that are related to electrical parts. The following are examples of this: the maximum downlink transmission capability at a given distance from earth; or the power capability of the primary power source, at the beginning of mission; or the memory capacity on the command and data subsystems. However, the total number of parts seems to be a better measure of complexity.

Figure 2, which concentrates on electrical & electronic PFRs, indicates that a higher percentage of P/Fs occur on electrical and electronic hardware for Galileo than for Voyager; the ratio of percentages being 1.19 (Galileo to Voyager). Also plotted in Figure 2 is the number of electrical parts for the Voyager and Galileo subsystems considered. The trend in the increase of

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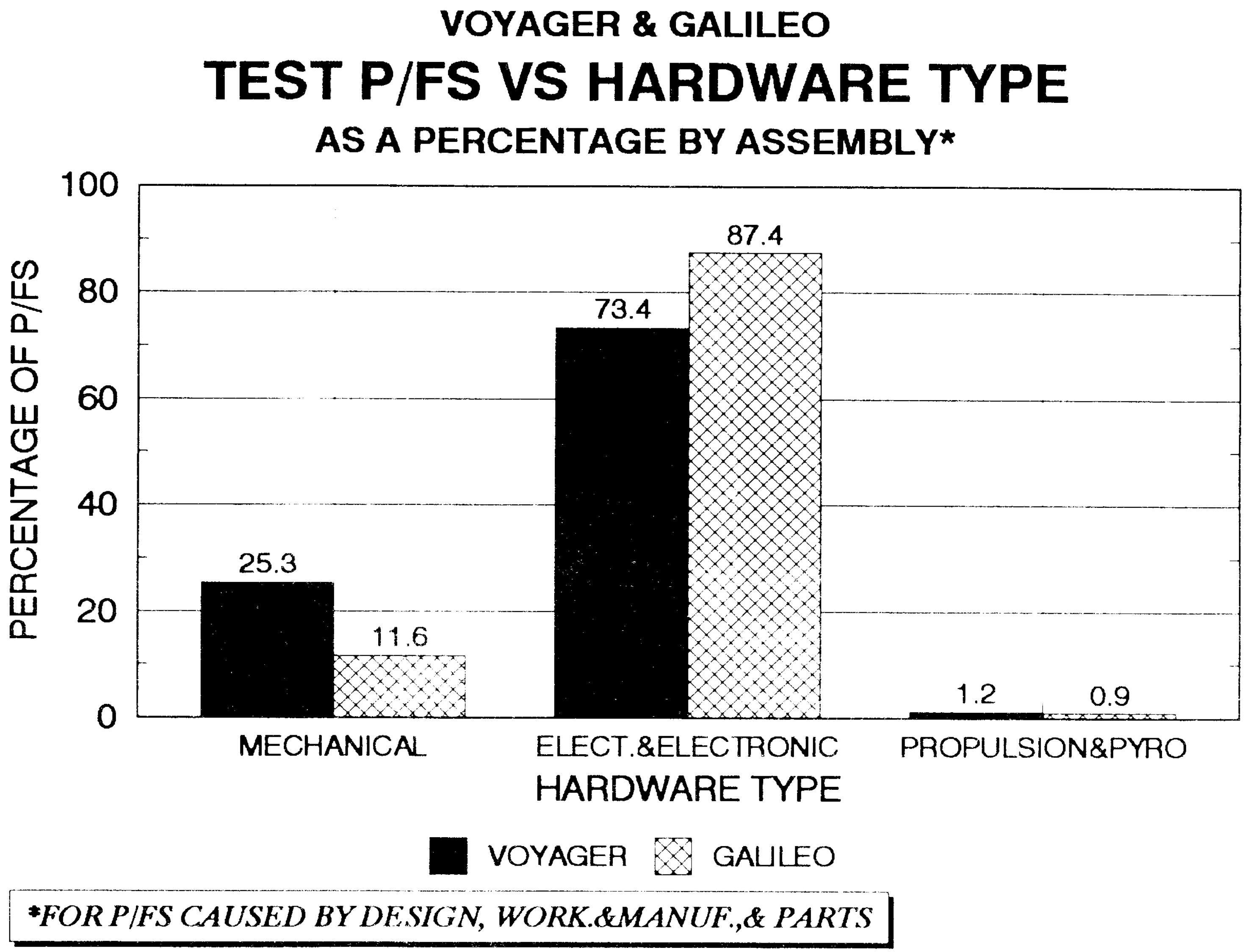
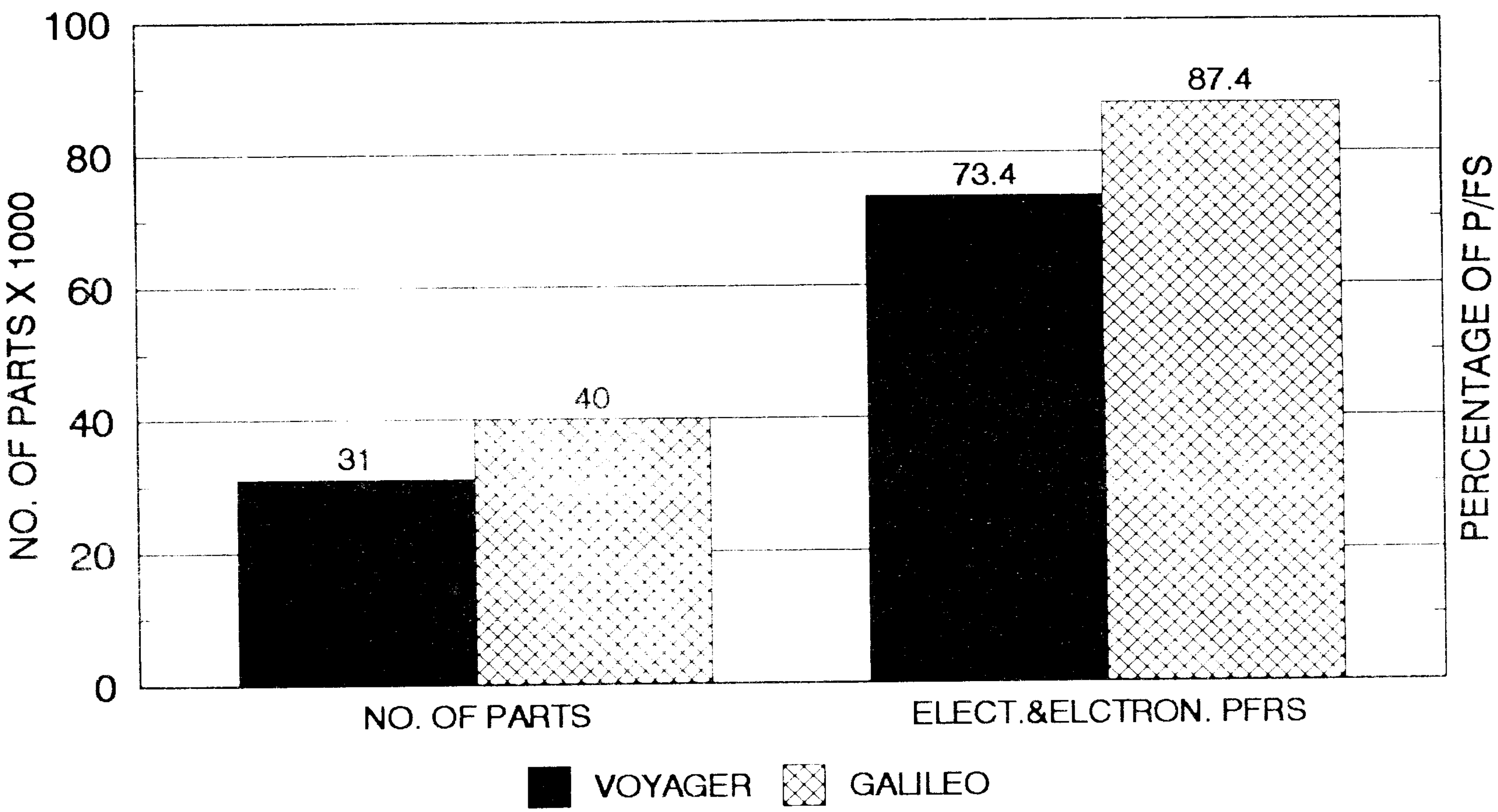

VOYAGER & GALILEO
TEST P/FS VS HARDWARE TYPE
AS A PERCENTAGE BY ASSEMBLY*
PERCENTAGE OF P/FS
100
80
60
40
20
0
25.3
11.6
73.4
87.4
1.2
0.9
MECHANICAL
ELECT.&ELECTRONIC
PROPULSION&PYRO
HARDWARE TYPE
VOYAGER
GALILEO
*FOR P/FS CAUSED BY DESIGN, WORK.&MANUF.,& PARTS

FIGURE 1

VOYAGER & GALILEO

ELECTRICAL/ELECTRONIC P/FS VS NO. OF PARTS

FOR SELECTED P/FS*



**FOR P/FS CAUSED BY DESIGN, WORK.&MANUF.,& PARTS*

FIGURE 2

PFRs follows the trend in the increase of parts for Voyager to Galileo from 31,000 to 40,000, a ratio of 1.29 (Galileo to Voyager). The ratios of the percentages of electrical & electronic PFRs differs from the ratios of part count by about 10 percent. Therefore, if the electrical complexity is directly related to the number of electrical parts in the hardware, the percentage of electrical and electronic P/Fs in Voyager and Galileo is related to their complexity.

A similar concept relating mechanical complexity to mechanical P/Fs may be possible. The form of the complexity factor may relate more to the state of the design and materials technology for mechanical systems than simply to the number of mechanical parts. In addition, mechanical functional redundancy is not common so that most mechanical assemblies represent a single failure point that has varying degrees of impact on the system. The issue of mechanical complexity and its relationship to problem/failures will be investigated in a future study.